

IN THE CLAIMS

Please amend Claims 2, 3 and 50 as follows. Please cancel Claims 21, 25-49 and 51-59 without prejudice or disclaimer. Claim 1 has been previously cancelled. Claims 2-20, 22-24 and 50 are currently pending. The listing of claims below will replace all prior versions, and listings, of claims in the application.

1. (Cancelled)
2. (Currently Amended) A bonding method for bonding objects to be bonded having a bonding portion formed of metal, comprising the following steps:
 - (a) treating said bonding portions of said objects to be bonded with an energy wave which is an atom beam, an ion beam, or a plasma to thereby clean the bonding portions of adhering substances;
 - (b) contacting said bonding portions of said objects to be bonded with each other in a low vacuum of 10^{-5} Torr or more in the atmospheric air; and
 - (c) crushing minute irregularities on a bonding surface of the bonding portions in contact with each other to an adhering substance layer readhering to said bonding portions by pressing said objects to be bonded, thereby bond the bonding objects to be bonded together, said adhering substance layer is formed of oxide film or organic substances, wherein
said bonding portions of objects to be bonded are formed of gold,
after step (a) and prior to step (b) at least some of the adhering substances readhere to the bonding portions to thereby form an adhering substance layer,
step (c) causes a bonding interface between the bonding portions to spread and new gold surface to appear at the bonding interface so that bonding is achieved between the bonding portions, and
steps (b) and (c) are each bonding objects to be bonded is performed in a solid phase at a temperature low temperatures between room temperature and 180°C.
3. (Currently Amended) A bonding method for bonding objects to be bonded having a bonding portion formed of metal comprising:

(a) treating said bonding portions of objects to be bonded with an energy wave which is an atom beam, an ion beam, or a plasma, ~~said bonding portion is formed by forming a gold film on a surface of a base material having a hardness of 200 Hv or less to thereby clean the bonding portions of adhering substances;~~

(b) contacting said bonding portions of object to be bonded with each other in a low vacuum of 10^{-5} Torr or more in the atmospheric air; and

(c) crushing minute irregularities on a bonding surface of the bonding portions in contact with each other to an adhering substance layer readhering to said bonding portions by pressing said objects to be bonded, thereby bond the bonding objects to be bonded together, said adhering substance layer is formed of oxide film or organic substances, wherein

each of said bonding portions is formed by forming a gold film in a solid phase on a surface of a base material having a hardness of 200 Hv or less,

after step (a) and prior to step (b) at least some of the adhering substances readhere to the bonding portions to thereby form an adhering substance layer,

step (c) causes a bonding interface between the bonding portions to spread and new gold surface to appear at the bonding interface so that bonding is achieved between the bonding portions,

steps (b) and (c) are each bonding objects to be bonded is performed in a solid phase at a temperature low temperatures between room temperature and 180°C, and

after said objects to be bonded are bonded together in step (c), said gold film is diffused into said base material.

4. (Original) The bonding method according to claim 3, wherein said object to be bonded is a semiconductor or a MEMS device in which said bonding portion comprises a plurality of metal bumps formed by forming said gold film on a surface of said base material, and said base material is copper, and after said objects to be bonded are bonded together, said gold film is diffused into the base material.

5. (Previously Presented) The bonding method according to claim 2, wherein said energy wave is a low-pressure plasma.

6. (Previously Presented) The bonding method according to claim 5, wherein at least one of said objects to be bonded is a semiconductor; and said bonding portion of each of said objects to be bonded is subjected to plasma cleaning using said low-pressure plasma which is generated with an electric field having alternating + and - directions generated by an alternating power supply before said objects to be bonded are bonded together in a solid phase at room temperature.

7. (Original) The bonding method according to claim 6, wherein said alternating power supply is an RF plasma generating power supply capable of controlling a value of a bias voltage Vdc.

8. (Original) The bonding method according to claim 6, wherein said alternating power supply is a pulsed wave generating power supply capable of controlling a pulse width.

9. (Previously Presented) The bonding method according to claim 2, wherein said bonding portion of at least one of said objects to be bonded has a surface roughness Ry of 120 nm or more.

10. (Original) The bonding method according to claim 9, comprising:

a head for holding one of said objects to be bonded;

a stage for holding said other object to be bonded; and

a vertical drive mechanism for performing a position control with respect to at least one of said head and said stage in a direction substantially perpendicular to said bonding surface of said object to be bonded, and performing a pressing control,

wherein, when said objects to be bonded are bonded together, during the bonding, said vertical drive mechanism is driven to press said objects to be bonded, and thereafter, said vertical drive mechanism is stopped to hold a constant height of said head from said stage for a predetermined time.

11. (Previously Presented) The bonding method according to claim 2, wherein, after said bonding portion of at least one of said objects to be bonded is subjected to leveling, said bonding

portion of each of said objects to be bonded is treated with said energy wave, and thereafter, said objects to be bonded are bonded together in a solid phase at room temperature.

12. (Original) The bonding method according to claim 11, wherein said leveling is performed using said opposing object to be bonded before said objects to be bonded are bonded together.

13. (Previously Presented) The bonding method according to claim 2, wherein in a chamber having a reduced pressure, while said bonding surfaces of said objects to be bonded are not placed facing each other, said bonding portions are treated with said energy wave, and thereafter, at least one of said objects to be bonded is moved so that said bonding surfaces are placed facing each other, and thereafter, at least one of said objects to be bonded is moved in a direction substantially perpendicular to said bonding surface to contact said bonding portions with each other, and bond said objects to be bonded together in a solid phase.

14. (Previously Presented) The bonding method according to claim 2, wherein, when said bonding portion is treated with said energy wave, a metal electrode is provided at a position facing said bonding surface of at least one of said objects to be bonded, a metal film including a metal forming said metal electrode is formed on said bonding surface of said object to be bonded by sputtering, and said objects to be bonded are bonded together in a solid phase.

15. (Previously Presented) The bonding method according to claim 2, wherein said bonding portion is formed in the shape of a contour, said bonding portion is surface-activated with said energy wave, and thereafter, said objects to be bonded are bonded together in a solid phase at room temperature, so that space surrounded in said shape of contour by said bonding portions is formed between said bonding surfaces of said objects to be bonded to enclose a predetermined atmosphere in said space.

16. (Previously Presented) The bonding method according to claim 15, wherein said bonding portion is formed on a surface of a base material having a hardness of 200 Hv or less,

and said bonding portion of at least one of said objects to be bonded is a gold plating having a thickness of 1 μm or more.

17. (Previously Presented) The bonding method according to claim 15, wherein bonding is performed in a vacuum, so that a vacuum atmosphere is enclosed in said space.

18. (Previously Presented) The bonding method according to claim 15, wherein, after said surface activation of said bonding portion, a vacuum state of a low-pressure chamber is replaced with filling gas, and said objects to be bonded are bonded in said filling gas to enclose said filling gas atmosphere in said space.

19. (Previously Presented) The bonding method according to claim 2, wherein said objects to be bonded are bonded together in the atmospheric air.

20. (Previously Presented) The bonding method according to claim 19, wherein one of the objects to be bonded is an electrically functioning device which employs the bonding portion as an electrode, and said bonding portion has a surface formed of gold, said bonding portion of the object to be bonded is cleaned with said energy wave, and thereafter, an attached layer is formed on said bonding portion using gas, said bonding portions including an metal electrode are contacted with each other in the atmospheric air, the positions of said objects to be bonded are adjusted to optimum positions while said device is caused to electrically function, and thereafter, said objects to be bonded are bonded together in a solid phase at room temperature.

21. (Cancelled)

22. (Previously Presented) The bonding method according to claim 19, wherein one of said objects to be bonded is a chip, and said other object to be bonded is a wafer on which a plurality of said chips are to be mounted, and a plurality of said chips are continuously bonded to said wafer.

23. (Original) The bonding method according to claim 22, wherein, during the time when said chips are continuously bonded to said wafer, after a predetermined time has passed, said wafer is treated again with said energy wave, and thereafter, bonding of said chips to said wafer is resumed.

24. (Previously Presented) The bonding method according to claim 2, wherein said object to be bonded is a chip or a wafer composed of a semiconductor or a MEMS device.

25-49. (Cancelled)

50. (Currently Amended) A bonding method for bonding objects to be bonded which have a bonding portion formed of metal, comprising:

(a) treating said bonding portions of objects to be bonded with a plasma to thereby clean the bonding portions of adhering substances;

(b) contacting said bonding portions of said objects to be bonded with each other in a low vacuum of 10^{-5} Torr or more in the atmospheric air; and

(c) crushing minute irregularities on a bonding surface of the bonding portions in contact with each other to an adhering substance layer readhering to said bonding portions by pressing said objects to be bonded, thereby bond the bonding objects to be bonded together, said adhering substance layer is formed of oxide film or organic substances, wherein

said bonding portions of objects to be bonded have a hardness of 20 Hv to 200 Hv,

after step (a) and prior to step (b) at least some of the adhering substances readhere to the bonding portions to thereby form an adhering substance layer,

step (c) causes a bonding interface between the bonding portions to spread and new gold surface to appear at the bonding interface so that bonding is achieved between the bonding portions, and

steps (b) and (c) are each bonding objects to be bonded is performed in a solid phase at a temperature low temperatures between room temperature and 180°C.

51-59. (Cancelled)